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CLIPPED OPTIMAL VIBRATION CONTROL OF SMART PIEZOLAMINATED BEAMS

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Summary. *Clipped optimal vibration control of smart laminated sandwich beams integrated with piezoelectric sensors and actuators is presented.*

1 INTRODUCTION

Piezoelectrics have emerged as the most widely used materials for distributed sensors and actuators in smart structures for active vibration, shape and noise control applications. There have been several studies on the active vibration control of smart piezoelectric laminated structures [1]. An optimal output feedback control of smart laminated beams was presented by Kapuria and Yasin [2] using an efficient and accurate laminate mechanics model. In such linear optimal control strategies, however, the control voltage applied on the piezoelectric actuators to suppress the vibration may exceed the threshold limit of the piezoelectric materials, which degrades their performance and may lead to the loss in their piezoelectric properties. For better performane, the control voltage on the actuators must be limited to the threshold limit. This work presents a study on the active vibration control of smart laminated beams using the clipped optimal control strategy [3] so as to limit the control voltage within a desired value. The performance of the clipped optimal control based on the linear quadratic Gaussian (LQG) controller is compared with the conventional LQG controller.

2 MODEL DESCRIPTION

The finite element model of Ref. [2] based on an efficient layerwise beam theory with quadratic variation of the electric potential across the thickness of piezoelectric layer is employed for the vibration analysis. The equipotential condition of electroded surfaces of sensors is satisfied exactly and conveniently using a novel concept of electric node. The control system is based on a reduced order model considering the first six modes. The closed-loop response is obtained by solving the dynamic equations in state space form using SIMULINK. Figure 1 shows the SIMULINK block diagram with unit step excitation.

3 RESULTS AND DISCUSSION

A five-layer hybrid sandwich beam with a soft core [2] of span 250 mm, width 10 mm and thickness 5 mm is considered for the numerical study. The laminate configuration and the material properties of the beam are taken from Ref. [2]. The beam is clamped at one end and excited by a step load of 0.8 N at the tip. The clipped control response for the deflection with actuation potential range of ±40 V is presented in Fig. 2 and compared with the response obtained using the conventional LQG controller. The output weighing parameter $\mathbf{Q}_Y$ is taken as 20**I**, and the sensor and plant noise intensities **V** and **W** are taken as $2.5\times10^{-5}V^2$ and 0.03 N^2, respectively. It is revealed from Fig. 2 that the performance of the clipped control with maximum actuation voltage of 40 V is practically the same as that of the LQG controller with a peak voltage of 67.7 V, both having the same settling time of 0.097 s.

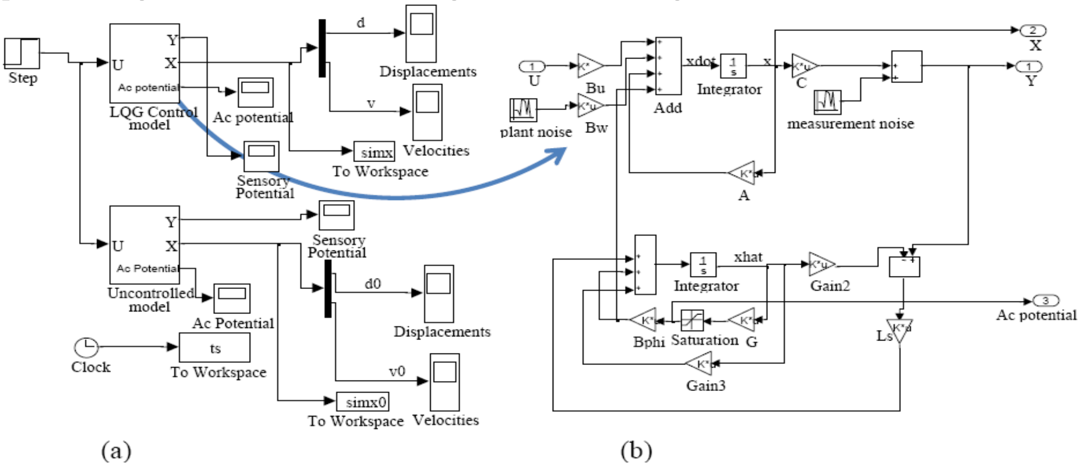

Figure 1: (a) Simulink model block diagram for overall process (b) Block diagram for clipped LQG control.

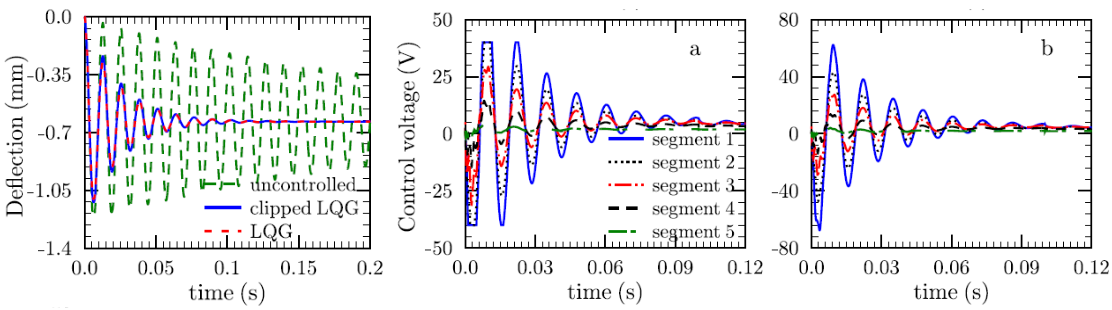

Figure 2: Deflection and control voltages for the smart sandwich beam: (a) clipped LQG, (b) LQG.

4 CONCLUSION

Using the clipped optimal control, the control voltages can be limited to a desired value, without significantly affecting the control performance of the system.

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